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(71)Applicant : FUJITSU LTD

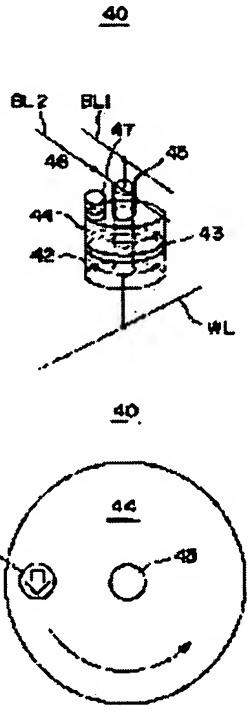
(72)Inventor : NAKAO HIROSHI
YAMASHITA YOSHIMI
HORIGUCHI NAOTO

(54) FERROMAGNETIC TUNNEL JUNCTION RANDOM ACCESS MEMORY, SPIN VALVE RANDOM-ACCESS MEMORY, SINGLE FERROMAGNETIC FILM RANDOM-ACCESS MEMORY AND MEMORY CELL ARRAY USING THEM

(57)Abstract:

PROBLEM TO BE SOLVED: To stably perform a write operation and a read operation by a method wherein a ferromagnetic layer which constitutes a ferromagnetic tunnel junction or a spin valve junction is formed annularly, so that the direction of magnetization of the ferromagnetic layer is not changed by a closure magnetic field even when a magnetic random-access memory is made fine.

SOLUTION: A conductive plug 45 which is composed of a nonmagnetic metal is formed so as to pass a ferromagnetic layer 42, a tunnel insulating film 43 and a ferromagnetic layer 44. A first bit line BL1 is connected to one end of the conductive plug 45, and a word line WL is connected to the other end. When a write current is made to flow to the conductive plug 45 constituted in this manner, the ferromagnetic layer 42 can be magnetized in the right-handed direction or its reverse left-handed direction. Then, when an antiferromagnetic film pattern 46 out of those of the ferromagnetic layer 44 is carried



by a part which is away from the conductive plug 45, the direction of the magnetization of the ferromagnetic layer 44 is pinned.

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(71)出願人　000005223
富士通株式会社
神奈川県川崎市中原区上小田中４丁目１番１号
(72)発明者　中尾　宏
神奈川県川崎市中原区上小田中４丁目１番１号　富士通株式会社内
(72)発明者　山下　良美
神奈川県川崎市中原区上小田中４丁目１番１号　富士通株式会社内
(74)代理人　100070150
弁理士　伊東　忠彦

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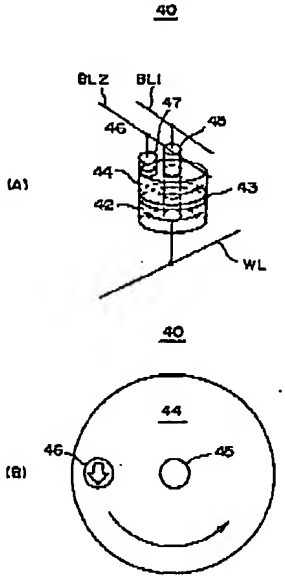
(54)【発明の名称】　強磁性トンネル接合ランダムアクセスメモリ、スピンバルブランダムアクセスメモリ、単一強磁性膜ランダムアクセスメモリ、およびこれらをつかったメモリセルアレイ

(57)【要約】
【課題】　微細化した場合でも安定に動作する磁気ランダムアクセスメモリを提供する。
【解決手段】　磁気ランダムアクセスメモリを、一対の強磁性リングとその間に介在するトンネル絶縁膜あるいは非磁性導電膜により構成し、さらに一方の強磁性リング上に、回転対称軸から外して反強磁性膜パターンをピニング層として形成し、前記強磁性リングの磁化方向をピニングする。

(A)，(B)は、本発明の第１実施例による磁気ランダムアクセスメモリの構成を示す図



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CLAIMS

[Claim(s)]
[Claim 1] The 1st ferromagnetic and the 2nd ferromagnetic which adjoins said 1st ferromagnetic, is formed and has the fixed magnetization, The ferromagnetic tunnel junction structure which consists of a tunnel insulator layer pinched between said 1st and 2nd ferromagnetics, The conductive plug which penetrates said the 1st ferromagnetic, said tunnel insulator layer, and said 2nd ferromagnetic along with a medial axis, It has the 1st selection line connected to the 1st edge of said conductive plug, and the 2nd selection line connected to the 2nd edge of an opposite hand of said conductive plug. Said 1st magnetic film It is the ferromagnetic tunnel junction random access memory which has a ring-like configuration surrounding said conductive plug, is insulated from said conductive plug, gets down, and is characterized by either of said 1st and 2nd ferromagnetics supporting an antiferromagnetism film pattern to the part.
[Claim 2] The 1st ferromagnetic and the 2nd ferromagnetic which adjoins said 1st ferromagnetic, is formed and has the fixed magnetization, The ferromagnetic tunnel junction structure which consists of a tunnel insulator layer pinched between said 1st and 2nd ferromagnetics, The conductive plug which penetrates said the 1st ferromagnetic, said tunnel insulator layer, and said 2nd ferromagnetic along with a medial axis, It has the 1st selection line connected to the 1st edge of said conductive plug, and the 2nd selection line connected to the 2nd edge of an opposite hand of said conductive plug. Said 1st magnetic film It is the ferromagnetic tunnel junction random access memory which has a ring-like configuration surrounding said conductive plug, is insulated from said conductive plug, gets down, and is characterized by one ferromagnetic of said ferromagnetics of the 1st and 2 having larger coercive force than the ferromagnetic of said another side.
[Claim 3] Ferromagnetic tunnel junction random access memory according to claim 1 or 2 furthermore characterized by avoiding said conductive plug and connecting the 3rd selection line electrically on said 1st ferromagnetic.
[Claim 4] Furthermore, ferromagnetic tunnel junction random access memory according to claim 3 characterized by avoiding said conductive plug and connecting the 4th selection line electrically on said 2nd ferromagnetic.
[Claim 5] Said 2nd selection line is ferromagnetic tunnel junction random access memory according to claim 3 characterized by consisting of a conductor pattern which connects electrically said the 2nd edge and said 2nd ferromagnetic of said conductive plug.
[Claim 6] It is the ferromagnetic tunnel junction random access memory according to claim 5 which said antiferromagnetism film pattern is supported on said 1st ferromagnetic, and is characterized by connecting said 3rd selection line to said 1st ferromagnetic through said antiferromagnetism film pattern.
[Claim 7] The 1st ferromagnetic and the 2nd ferromagnetic which was adjoined and formed in said 1st ferromagnetic and which has the fixed magnetization, The spin bulb junction structure which consists of nonmagnetic electric conduction film pinched between said 1st and 2nd ferromagnetics, Said the 1st ferromagnetic, said tunnel insulator layer, and said 2nd ferromagnetic are penetrated for the inside of

said spin bulb junction structure. The conductive plug which extends along with a medial axis, and the 1st selection line connected to the 1st edge of said conductive plug, The 2nd selection line connected to the 2nd edge of an opposite hand of said conductive plug, The 3rd selection line connected to the 1st location on the side-attachment-wall side of said spin bulb junction structure, It has the 4th selection line connected to the 2nd location which counters said 1st location on said side-attachment-wall side of said spin bulb junction structure. Said 1st magnetic film It is the spin bulb random access memory which has a ring-like configuration surrounding said conductive plug, is insulated from said conductive plug, gets down, and is characterized by either of said 1st and 2nd ferromagnetics supporting an antiferromagnetism film pattern to the part.

[Claim 8] It is the single ferromagnetic random access memory characterized by consisting of a ferromagnetic, the conductive plug which penetrates the center section of said ferromagnetic, the 1st selection line connected to the 1st edge of said conductive plug, and the 2nd selection line connected to the 2nd edge of an opposite hand of said conductive plug, and for said ferromagnetic having a ring-like configuration surrounding said conductive plug, and insulating from said conductive plug.

[Claim 9] In the memory cell array which arranged two or more memory cells which consist of ferromagnetic tunnel junction random access memory which has the configuration which each indicated to claim 5 in the shape of a matrix a group which aligned in the 1st direction into said memory cell array -- a memory cell Said 1st selection line is connected to the 1st common selection line which extends in said 1st direction in the inside of said magnetic memory cell array. For said 3rd selection line, the inside of said memory cell array in said 1st direction a group which aligned in the direction in which it connected with the 2nd common selection line which extends on said 1st common selection line at parallel, and the 2nd differed in said memory cell array -- a memory cell It is the memory cell array which is connected to the 3rd common selection line which extends the inside of said memory cell array in said 2nd direction in said 2nd selection line, and is characterized by each memory cell including the switch inserted between said 3rd common selection line and said 2nd selection line.

[Claim 10] In the memory cell array which arranged two or more memory cells which consist of ferromagnetic TONRU junction random access memory which has the configuration which each indicated to claim 4 in the shape of a matrix a group which aligned in the 1st direction into said memory cell array -- a memory cell Said 1st and 3rd selection lines are connected to the 1st common selection line which extends in said 1st direction in the inside of said magnetic memory cell array. a group which aligned in the direction in which the 2nd differed in said memory cell array -- a memory cell Said 2nd and 4th selection lines are connected to the 2nd common selection line which extends in said 2nd direction in the inside of said memory cell array. Each memory cell The 1st diode inserted between said 2nd common selection line and said 2nd selection line, The memory cell array characterized by having a different property from said 1st diode and said 2nd diode including the 2nd diode inserted between said 2nd common selection line and said 4th selection line.

[Claim 11] In the memory cell array which arranged two or more memory cells which consist of spin bulb random access memory which has the configuration which each indicated to claim 7 in the shape of a matrix a group which aligned in the 1st direction into said memory cell array -- a memory cell Said 1st and 3rd selection lines are connected to the 1st common selection line which extends in said 1st direction in the inside of said magnetic memory cell array. a group which aligned in the direction in which the 2nd differed in said memory cell array -- a memory cell Said 2nd and 4th selection lines are connected to the 2nd common selection line which extends in said 2nd direction in the inside of said memory cell array. Each memory cell The 1st diode inserted between said 2nd common selection line and said 2nd selection line, The memory cell array characterized by having a different property from said 1st diode and said 2nd diode including the 2nd diode inserted between said 2nd common selection line and said 4th selection line.

[Claim 12] In the memory cell array which arranged two or more magnetic random access memory which each indicated to claim 8 in the shape of a matrix a group which aligned in the 1st direction into said memory cell array -- a memory cell Said 1st selection line is connected to the 1st common selection line which extends in said 1st direction in the inside of said magnetic memory cell array. a group which

aligned in the direction in which the 2nd differed in said memory cell array -- a memory cell It is the memory cell array which is connected to the 2nd common selection line which extends the inside of said memory cell array in said 2nd direction in said 2nd selection line, and is characterized by inserting diode in each memory cell between said 2nd common selection line and said 2nd selection line.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] Generally this invention relates to magnetic memory, especially relates to ferromagnetic random access memory and its manufacture approach. Random access memory is indispensable as main storage in information processors, such as a computer. It is also possible to constitute by the magnetic random access memory using magnetic reluctance conventionally, although random access memory is constituted by semiconductor memories, such as DRAM. Magnetic random access memory has the simple configuration which pinched the nonmagnetic membrane which consists of an insulator or a conductor between the ferromagnetics of a couple, and is suitable for detailed-izing and integration. Generally the magnetic random access memory which furthermore starts is nonvolatile, and since it has the outstanding response characteristic, it is thought as memory of a future very high speed computer that it is promising. magnetic random access memory -- for example -- Parkin, S.S.P., et al., J.Apply.Phys.vol.85, pp.5828, and 1999 -- reference.
[0002]
[Description of the Prior Art] Drawing 1 and Parkin The configuration [/ else (above)] of the magnetic random access memory (MRAM) 10 using a ferromagnetic tunnel junction is shown. With reference to drawing 1 , the pinning layer 11 which consists of an antiferromagnetism ingredient is formed on the word line pattern WL which extends in a line writing direction, and the pinned layer 12 which consists of a ferromagnetic ingredient is formed on said pinning layer 11. In said pinned layer 11, there is no magnetization direction in the direction of an arrow head, and pinning is carried out by said antiferromagnetism pinning layer 11 under it. The free layer 14 which furthermore separates the nonmagnetic tunnel insulator layer 13 on said pinned layer 12, and consists of a ferromagnetic ingredient is formed, and the bit line pattern BL which extends in the direction of a train is formed on said free layer 14. Said free layer 14 is magnetized by the synthetic magnetic field in which the flowing write-in current forms said word line WL and said bit line BL in the direction shown by the arrow head in drawing 1 R> 1, or its opposite direction in that case. A paraphrase writes in information for said MRAM10 in the form of magnetization of said free layer 14.
[0003] On the other hand, in order to read the information written in in this MRAM10, the magnetic reluctance of the ferromagnetic tunnel junction which consists of said pinned layer 12 and free layer 14, and a nonmagnetic tunnel insulator layer 13 which intervenes in between is used. If it explains more concretely, spin polarization has arisen in conduction electron in a ferromagnetic like said free layer 14 or a pinned layer 12, and the number of rise spin electrons differs from the number of down spin electrons. When the magnetization direction of said free layer 14 and pinned layer 12 is parallel, the rise spin electron or down spin electron in the free layer 14 can be tunneled through said tunnel insulator layer 13 to the empty level of the corresponding electron of a spin state which exists all over a pinned layer 12, and said ferromagnetic tunnel junction shows low resistance. On the other hand, when the magnetization directions of said free layer 14 and pinned layer 12 are anti-parallel, the empty level corresponding to the rise spin electron or down spin electron in the free layer 14 does not exist all over a

pinned layer 12, and, for this reason, electronic tunneling is not produced in said tunnel insulator layer 13. When it puts in another way and the pinned layer 12 of said free layer 14 is in an anti-parallel condition magnetically, said ferromagnetic tunnel junction shows big resistance.
[0004] So, in MRAM10 of drawing 1 , the information written in into said free layer 14 can be read by detecting the electrical potential difference between said word lines WL and bit lines BL. Saving a power source, even if the information written in in the form of magnetization into this free layer 14 is off, as a result, said MRAM10 constitutes nonvolatile memory. Moreover, even if it performs resistance detection of last mind, magnetization of the free layer 14 is not reversed and, for this reason, destructive read is possible in said MRAM10.
[0005]
[Problem(s) to be Solved by the Invention] On the other hand, if detailed-ization is advanced in MRAM10 of drawing 1 , the rate of surface area to the volume of the magnetic substance will increase, and a magnetic domain as shown in the ferromagnetic layer of these at drawing 2 (B) will arise under the effect of the reflux magnetic field generated by magnetization of said free layer 14 or a pinned layer 12 as shown in drawing 2 (A). If such a magnetic domain is formed, since magnetization will disappear as a whole seemingly, a ferromagnetic tunnel junction cannot operate. In order to avoid this problem, it is necessary to use the ingredient which has said ferromagnetic layer 12 or the big coercive force about 14 but, and when such an ingredient is used, a high current will be needed for writing. For example, when it is going to form the magnetic field of 10Oe extent which flux reversal takes with the current passed to the word line WL formed in the location of MRAM10 to 100nm of drawing 1 , a several mA current is needed, but when this high current is passed to the word line WL formed with 0.1-micrometer rule, current density will also become 107 A/cm2.
[0006] On the other hand, the thing of the spin bulb configuration shown in drawing 3 is known as MRAM which was suitable for detailed-ization conventionally (Patent Publication Heisei No. 509775 [nine to] official report). With reference to drawing 3 , MRAM20 has MRAM10 of the point, and a similar laminated structure, and, similarly the nonmagnetic conductive layer 23 is inserted between said pinned layers 22 and free layers 24 including the disk-like strong magnetic pinned layer 22 and the ferromagnetic free layer 24 of the shape of a ring formed on said pinned layer 22 which were formed on the antiferromagnetism pinning layer 21 of the shape of a disk formed on the word line pattern WL, and said pinning layer 21. Moreover, on said free layer 24, the bit line BL which extends in the direction which intersects said word line pattern WL is formed. the magnetic reluctance observed between said word line patterns WL and bit line patterns BL as a result of dispersion for which it depended in the spin direction of the electron produced in the interface of said strong magnetic pinned layer 22 and nonmagnetic conductive layer 23, and the interface of said nonmagnetic conductive layer 23 and the ferromagnetic free layer 24 in this spin bulb mold MRAM -- the magnetization direction of said ferromagnetic free layer 24 -- it changes with how.
[0007] In MRAM20 of the configuration of drawing 3 , since the direction of a reflux magnetic field is in agreement in the magnetization direction when said magnetic layers 22 and 24 are magnetized right-handed rotation or in the counterclockwise direction along with the circumferencial direction, since each ferromagnetic layers 22 and 24 have a disk configuration, even if it makes it detailed, the magnetic domain explained by drawing 2 (B) is not formed. On the other hand, in the spin bulb mold MRAM20 of drawing 3 , since said ferromagnetic layers 22 and 24, the antiferromagnetism layer 21, and a non-magnetic layer 23 are conductive layers altogether, its resistance between a bit line BL and a word line WL is low, and it has the trouble that a big current is needed for magnetic-reluctance detection at the time of read-out for this reason.
[0008] Furthermore, in MRAM20 of drawing 3 , setting the magnetization direction of said pinned layer 22 as a desired circumferencial direction has a difficult trouble. That is, in MRAM20 of drawing 3 , since said antiferromagnetism pinning layer 21 is formed all over the bottom principal plane of said pinned layer 22, when the magnetization direction of said pinned layer 22 is fixed by magnetization of said pinning layer 21 under existence of an external magnetic field, the magnetization direction is only fixed to an one direction, and the magnetization in alignment with a desired circumferencial direction is

not obtained.
[0009] Then, this invention makes it a general technical problem to offer the new and useful magnetic random access memory which solved the above-mentioned technical problem, and its manufacture approach. The more concrete technical problem of this invention is suitable for detailed-ization, it is easy to manufacture and it is to offer the memory cell array using the magnetic random access memory which shows a big resistance change and its manufacture approach, and the magnetic random access memory which starts further.
[0010]
[Means for Solving the Problem] As indicated to claim 1, this invention the above-mentioned technical problem The 1st ferromagnetic, The 2nd ferromagnetic which adjoins said 1st ferromagnetic, is formed and has the fixed magnetization, The ferromagnetic tunnel junction structure which consists of a tunnel insulator layer pinched between said 1st and 2nd ferromagnetics, The conductive plug which penetrates said the 1st ferromagnetic, said tunnel insulator layer, and said 2nd ferromagnetic along with a medial axis, It has the 1st selection line connected to the 1st edge of said conductive plug, and the 2nd selection line connected to the 2nd edge of an opposite hand of said conductive plug. Said 1st magnetic film It has a ring-like configuration surrounding said conductive plug, and it insulates from said conductive plug and gets down. Either of said 1st and 2nd ferromagnetics By the ferromagnetic tunnel junction random access memory characterized by supporting an antiferromagnetism film pattern to the part Or the 2nd ferromagnetic which has the magnetization which adjoined the 1st ferromagnetic and said 1st ferromagnetic, was formed, and was fixed as indicated to claim 2, The ferromagnetic tunnel junction structure which consists of a tunnel insulator layer pinched between said 1st and 2nd ferromagnetics, The conductive plug which penetrates said the 1st ferromagnetic, said tunnel insulator layer, and said 2nd ferromagnetic along with a medial axis, It has the 1st selection line connected to the 1st edge of said conductive plug, and the 2nd selection line connected to the 2nd edge of an opposite hand of said conductive plug. Said 1st magnetic film It has a ring-like configuration surrounding said conductive plug, and it insulates from said conductive plug and gets down. One ferromagnetic of said ferromagnetics of the 1st and 2 By the ferromagnetic tunnel junction random access memory characterized by having larger coercive force than the ferromagnetic of said another side As indicated to claim 3, further or on said 1st ferromagnetic By the ferromagnetic tunnel junction random access memory according to claim 1 or 2 characterized by avoiding said conductive plug and connecting the 3rd selection line electrically As indicated to claim 4, further or on said 2nd ferromagnetic By the ferromagnetic tunnel junction random access memory according to claim 3 characterized by avoiding said conductive plug and connecting the 4th selection line electrically As indicated to claim 5, or said 2nd selection line By the ferromagnetic tunnel junction random access memory according to claim 3 characterized by consisting of a conductor pattern which connects electrically said the 2nd edge and said 2nd ferromagnetic of said conductive plug As indicated to claim 6, or said antiferromagnetism film pattern It is supported on said 1st ferromagnetic. Said 3rd selection line By the ferromagnetic tunnel junction random access memory according to claim 5 characterized by connecting with said 1st ferromagnetic through said antiferromagnetism film pattern Or the 2nd ferromagnetic which was adjoined and formed in the 1st ferromagnetic and said 1st ferromagnetic as indicated to claim 7 and which has the fixed magnetization, The spin bulb junction structure which consists of nonmagnetic electric conduction film pinched between said 1st and 2nd ferromagnetics, Said the 1st ferromagnetic, said tunnel insulator layer, and said 2nd ferromagnetic are penetrated for the inside of said spin bulb junction structure. The conductive plug which extends along with a medial axis, and the 1st selection line connected to the 1st edge of said conductive plug, The 2nd selection line connected to the 2nd edge of an opposite hand of said conductive plug, The 3rd selection line connected to the 1st location on the side-attachment-wall side of said spin bulb junction structure, It has the 4th selection line connected to the 2nd location which counters said 1st location on said side-attachment-wall side of said spin bulb junction structure. Said 1st magnetic film It has a ring-like configuration surrounding said conductive plug, and it insulates from said conductive plug and gets down. Either of said 1st and 2nd ferromagnetics By the spin bulb random access memory characterized by supporting an

antiferromagnetism film pattern to the part Or the conductive plug which penetrates the center section of a ferromagnetic and said ferromagnetic as indicated to claim 8, It consists of the 1st selection line connected to the 1st edge of said conductive plug, and the 2nd selection line connected to the 2nd edge of an opposite hand of said conductive plug. Said ferromagnetic By the single ferromagnetic random access memory characterized by having a ring-like configuration surrounding said conductive plug, and insulating from said conductive plug Or as indicated to claim 9, the memory cell which consists of ferromagnetic tunnel junction random access memory which has the configuration which each indicated to claim 5 is set to the memory cell array arranged in the shape of a matrix. [two or more] a group which aligned in the 1st direction into said memory cell array -- a memory cell Said 1st selection line is connected to the 1st common selection line which extends in said 1st direction in the inside of said magnetic memory cell array. For said 3rd selection line, the inside of said memory cell array in said 1st direction a group which aligned in the direction in which it connected with the 2nd common selection line which extends on said 1st common selection line at parallel, and the 2nd differed in said memory cell array -- a memory cell Said 2nd selection line is connected to the 3rd common selection line which extends in said 2nd direction in the inside of said memory cell array. Each memory cell It is an account to the memory cell array characterized by including the switch inserted between said 3rd common selection line and said 2nd selection line, or claim 10. In the memory cell array which arranged two or more memory cells which consist of ferromagnetic TONRU junction random access memory which has the configuration which each indicated to claim 4 as it **(ed) in the shape of a matrix a group which aligned in the 1st direction into said memory cell array -- a memory cell Said 1st and 3rd selection lines are connected to the 1st common selection line which extends in said 1st direction in the inside of said magnetic memory cell array. a group which aligned in the direction in which the 2nd differed in said memory cell array -- a memory cell Said 2nd and 4th selection lines are connected to the 2nd common selection line which extends in said 2nd direction in the inside of said memory cell array. Each memory cell The 1st diode inserted between said 2nd common selection line and said 2nd selection line, The 2nd diode inserted between said 2nd common selection line and said 4th selection line is included. Said the 1st diode and said 2nd diode As indicated to the memory cell array characterized by having a different property, or claim 11 In the memory cell array which arranged two or more memory cells which consist of spin bulb random access memory which has the configuration which each indicated to claim 7 in the shape of a matrix a group which aligned in the 1st direction into said memory cell array -- a memory cell Said 1st and 3rd selection lines are connected to the 1st common selection line which extends in said 1st direction in the inside of said magnetic memory cell array. a group which aligned in the direction in which the 2nd differed in said memory cell array -- a memory cell Said 2nd and 4th selection lines are connected to the 2nd common selection line which extends in said 2nd direction in the inside of said memory cell array. Each memory cell The 1st diode inserted between said 2nd common selection line and said 2nd selection line, The 2nd diode inserted between said 2nd common selection line and said 4th selection line is included. Said the 1st diode and said 2nd diode As indicated to the memory cell array characterized by having a different property, or claim 12 In the memory cell array which arranged two or more magnetic random access memory which each indicated to claim 8 in the shape of a matrix a group which aligned in the 1st direction into said memory cell array -- a memory cell Said 1st selection line is connected to the 1st common selection line which extends in said 1st direction in the inside of said magnetic memory cell array. a group which aligned in the direction in which the 2nd differed in said memory cell array -- a memory cell Said 2nd selection line is connected to the 2nd common selection line which extends the inside of said memory cell array in said 2nd direction, and each memory cell is solved by the memory cell array characterized by inserting diode between said 2nd common selection line and said 2nd selection line.

According to [operation] this invention, in ferromagnetic tunnel junction random access memory or spin bulb random access memory, it can be set as the circumferencial direction surrounding the write-in current path which penetrates said ferromagnetic tunnel junction or spin bulb junction for the magnetization direction of said pinned layer by not being all over a pinned layer and forming only in the part the pinning layer which fixes the magnetization direction of a pinned layer. By said ferromagnetic

tunnel junction random access memory or spin bulb random access memory, detailed-ization not more than it to conventionally impossible extent is attained by the effectiveness of a reflux magnetic field by setting up the magnetization direction of a pinned layer in the direction of right-handed rotation, or the direction of left-handed rotation to a write-in current in this way.

[0011] When using a ferromagnetic tunnel junction, the resistance of memory can increase according to the effectiveness of a tunnel insulator layer, as a result, a write-in current or a read-out current can decrease, and the power consumption of memory can be reduced. on the other hand, when using spin bulb junction, the problem of power consumption buildup of the memory by resistance which had been produced in the conventional spin bulb mold magnetic random access memory in which reading appearance is carried out, and the current path at the time is formed in the field of said ferromagnetic at parallel, consequently a current path is formed at right angles to a ferromagnetic and which is too low is solved.

[0012] Furthermore, the magnetic random access memory which combined with the single ring-like ferromagnetic the current path which penetrates this can raise an accumulation consistency, when structure can be easy, can also decrease the number of selection lines and constitutes a memory cell array. Furthermore, when it constitutes a memory cell array for said ferromagnetic tunnel junction random access memory, spin bulb random access memory, or single ferromagnetic random access memory using a memory cell, it becomes possible by preparing non-line type components, such as switches, such as a transistor, or diode, in each memory cell to supply a write-in current or a read-out current only to the selected memory cell.

[0013]

[Embodiment of the Invention] The perspective view and drawing 4 (B) which show the configuration of MRAM40 according [drawing 4 (A)] to the 1st example of this invention are the top view of MRAM40. the ferromagnetic ring 42 with which 60nm and an outer diameter is [a bore] 120nm, for example, as for MRAM40, thickness has the structure which carried out the laminating of a FeNi alloy layer and the Co layer by 20nm with reference to drawing 4 (A) -- containing -- said ferromagnetic ring 42 top -- thickness -- typical -- 2nm aluminum 2O3 etc. -- the becoming tunnel insulator layer 43 is formed. Said tunnel insulator layer is aluminum 2O3. When it forms, on said ferromagnetic ring 42, thin aluminum layer with a thickness of several nm or less is deposited, and the front face is formed natural oxidation or by carrying out plasma oxidation. Thus, generally the formed tunnel insulator layer is aluminum 2O3. From stoichiometric composition, it separates from some, and is AlOx. It has the presentation expressed. Furthermore, on said tunnel insulator layer 43, said ferromagnetic ring 42 and another ferromagnetic ring 44 of the same configuration are formed in same axle to said ferromagnetic ring 42.

[0014] Furthermore, the conductive plug 45 which pierces through said ferromagnetic ring 42, the tunnel insulator layer 43, and the ferromagnetic ring 44, and consists of non-magnetic metal, such as W, Cu, Ag, and Pt, in MRAM40 of drawing 4 (A) is formed, and it is the 1st bit line BL1 to the end of said conductive plug 45. A word line WL is connected to the other end. By passing a write-in current to said conductive plug 45, into said ferromagnetic 42, as the drawing Nakaya mark shows, in this configuration, magnetization can be formed in the direction of the circumference of a right hand, or the direction of the circumference of a left hand of reverse.

[0015] MRAM40 supports the antiferromagnetism film pattern 46 which becomes the part which separated from said conductive plug 45 among on said ferromagnetic ring 44 further, and the part which separated from the symmetry axis of rotation inversion of said ferromagnetic ring 44 when put in another way from Mn system antiferromagnetism ingredients, such as PtMn or PdPtMn, preferably, and pinning of the direction of the magnetization in said ferromagnetic ring 44 is carried out in the direction of the arrow head of drawing 4 (A) with said antiferromagnetism film 46.

[0016] Drawing 4 (B) shows pinning of the magnetization direction of the ferromagnetic ring 44 by the diamagnetism film pattern 46. Although said diamagnetism film pattern 46 does not show magnetization as the whole with reference to drawing 4 R> 4 (B), in an interface with said ferromagnetic ring 44, magnetization of the direction shown with a bold arrow can be formed into drawing 4 (B) by impressing

a uniform external magnetic field. Then, the magnetization direction of said ferromagnetic ring 44 is set up in the direction of the circumference of a left hand in the example of drawing 4 (B) by magnetizing said ferromagnetic ring 44 all over the magnetic field which such a diamagnetism film pattern 46 forms. In order that said antiferromagnetism film pattern 46 may not show magnetization as a whole, even if it is stable, it writes in said conductive plug 45, it supplies a current and it reverses magnetization of said ferromagnetic ring 42 to external magnetization, the magnetization direction of the ferromagnetic ring 44 does not change. Moreover, in the ferromagnetic layer of the shape of this ring, since a reflux magnetic field is in agreement with magnetization of a circumferencial direction, it becomes possible to perform detailed-ization, without disturbing the magnetization direction. That is, it becomes possible to constitute the high-speed-storage equipment of the non-volatile which has very big storage capacity by MRAM40 of drawing 4 (A) and (B) being suitable for high density accumulation, and constituting the memory cell array explained later.

[0017] Furthermore, by said MRAM40, as shown in drawing 4 (A), the nonmagnetic electric conduction plug 47 which consists of Cu, Pt, Ag, etc. is formed on said antiferromagnetism pattern 46, and it is said bit line BL1 to said nonmagnetic electric conduction plug 47. Another bit line BL2 which extends in parallel is connected. Then, since tunnel current flows from said ferromagnetic ring 44 through said tunnel insulator layer 43 to said ferromagnetic ring 42 when the magnetization direction in said ferromagnetic ring 42 is in agreement with the magnetization direction in said ferromagnetic ring 44, it is said 2nd bit line BL2. The resistance between word lines WL has the 1st low value. On the other hand, the tunnel current which minded said tunnel insulator layer 43 when the magnetization direction in said ferromagnetic ring 42 was the magnetization direction and reverse in said ferromagnetic ring 44 is said 2nd bit line BL2, in order not to flow. The resistance between said word lines WL has the 2nd bigger value. Then, such a word line WL and a bit line BL2 By detecting the resistance of a between, the information written in in the form of magnetization into said MRAM40 can be read. However, with the configuration of drawing 4 (A) and (B), although said conductive plug 45 is insulated to said ferromagnetic ring 44, said ferromagnetic ring 42 and conductive plug 45 are connected electrically. Or said ferromagnetic ring 42 and conductive plug 45 may be insulated, and the ferromagnetic ring 44 and the conductive plug 45 may be connected electrically. The fine structure of said MRAM40 is explained in the example after indicating the manufacture approach.

[0018] on the other hand, when information was written in into said MRAM40, also in advance, it explained -- as -- said bit line BL1 between word lines WL -- writing in -- a current -- said word line WL to bit line BL1 Or said bit line BL1 from -- the magnetization direction in a sink and said ferromagnetic ring 42 is reversed to a word line WL. Since pinning of the magnetization of said ferromagnetic ring 44 is carried out with said antiferromagnetism film pattern 46 in the case of this writing as explained also in advance, reversal of magnetization does not arise in said ferromagnetic ring 44.

[0019] In addition, in MRAM40 of drawing 4 (A) and (B), as long as said ferromagnetic ring 42 or the appearance of 44 is the configuration in which it is not circularly limited and a reflux magnetic field is included, what kind of thing is sufficient as a polygon configuration etc. Drawing 5 shows MRAM40A by the example of the example of a complete-change form of MRAM40 of drawing 4 (A) and (B). However, the same reference mark is given to the part explained previously among drawing 5 , and explanation is omitted.

[0020] With reference to drawing 5 , said antiferromagnetism film 46 and said nonmagnetic electric conduction plug 47 are formed in the location where it differed on said ferromagnetic ring 44 by this example, respectively. That is, in this example, said nonmagnetic electric conduction plug 47 is directly formed on said ferromagnetic ring 44. Also in the configuration of drawing 5 , it becomes possible by carrying out pinning of the magnetization direction of said ferromagnetic ring 44 with said antiferromagnetism film pattern 46, and detecting resistance change of the ferromagnetic tunnel junction by the magnetization direction of said ferromagnetic ring 42 to read the information written in in the form of magnetization into said ferromagnetic ring 42. Moreover, informational writing is performed by writing in said conductive plug 45 and passing a current like MRAM40 of drawing 4 (A) and (B).

[2nd example] drawing 6 shows the configuration of MRAM40B by the 2nd example of this invention.

However, the same reference mark is given to the part explained previously among drawing 6 , and explanation is omitted.
[0021] Although MRAM40B has MRAM40A of drawing 5 , and a similar configuration with reference to drawing 6 word line WL1 connected to said conductive plug 45 instead of the single word line WL Word line WL2 connected to said ferromagnetic ring 42 through said conductive plug 47 and the same conductive plug (not shown) It has and is said word line WL1. Since it is informational writing, it is a word line WL2. It is used for read-out of information. Namely, said word line WL1 Bit line BL1 By choosing, it writes in said conductive plug 45, a current flows, and informational writing is made to said ferromagnetic ring 42. On the other hand, it is said word line WL2. Bit line BL2 By choosing, the content of the information by which resistance of the tunnel current path which passes along said tunnel insulator layer 44 was detected, and was written in said ferromagnetic ring 42 in the form of magnetization based on the value of the detected resistance is judged.
[0022] That is, the same actuation as said MRAM40 or 40A is obtained by MRAM40B of drawing 6 .
[3rd example] drawing 7 shows the configuration of MRAM40C by the 3rd example of this invention. However, the same reference mark is given to the part explained previously among drawing 7 , and explanation is omitted.
[0023] Although MRAM40C has MRAM40 of drawing 4 or MRAM40of drawing 5 A, and a similar configuration with reference to drawing 7 , it has ferromagnetic pattern 44A magnetized in the direction of an arrow head instead of said ferromagnetic ring 44. Said ferromagnetic pattern 44A extends in the magnetization direction, and is constituted by the ferromagnetic ingredient with larger coercive force than said ferromagnetic ring 42.
[0024] With this configuration, it writes in said conductive plug 45, and even if it reverses the magnetization direction of a sink and said ferromagnetic ring 42 for a current, the magnetization direction of said ferromagnetic pattern 44A does not change, but, as a result, the same writing and read-out actuation as said MRAM40 or 40A are possible for it.
[4th example] drawing 8 shows the configuration of MRAM50 by the 4th example of this invention.
[0025] With reference to drawing 8 , MRAM50 has the configuration of a spin bulb mold, by 20nm, a bore is 60nm, and an outer diameter is 120nm, for example, thickness contains the ferromagnetic ring 52 which has the structure which carried out the laminating of a FeNi alloy layer and the Co layer. On said ferromagnetic ring 52, the nonmagnetic rings 53, such as 1.5nm aluminum or Cu, are typically formed for thickness, and said ferromagnetic ring 52 and another ferromagnetic ring 54 of the same configuration are further formed in same axle to said ferromagnetic ring 52 and the nonmagnetic ring 43 on said nonmagnetic ring 53.
[0026] Furthermore, the conductive plug 55 which pierces through said ferromagnetic ring 52, the nonmagnetic ring 53, and the ferromagnetic ring 54, and consists of non-magnetic metal, such as W, Cu, Ag, and Pt, is formed, and it is the 1st bit line BL1 to the end of said conductive plug 55. It is a word line WL1 to the other end. It connects. By passing a write-in current to said conductive plug 55, into said ferromagnetic 52, as the drawing Nakaya mark shows, in this configuration, magnetization can be formed in the direction of the circumference of a right hand, or the direction of the circumference of a left hand of reverse.
[0027] MRAM50 supports the antiferromagnetism film pattern 56 which becomes the part which separated from said conductive plug 55 among on said ferromagnetic ring 54 further, and the part which separated from the symmetry axis of rotation inversion of said ferromagnetic ring 54 when put in another way from Mn system antiferromagnetism ingredients, such as PtMn or PdPtMn, preferably, and pinning of the direction of the magnetization in said ferromagnetic ring 54 is carried out in the direction of the arrow head of drawing 8 with said antiferromagnetism film 56. Furthermore, MRAM50 of drawing 8 has the conductive plugs 57A and 57B in the location which counters on both sides of said symmetry axis of rotation inversion among the spin bulb junction structures which consist of said rings 52-54.
[0028] Among these, in said conductive plug 57A, it is a bit line BL2. It connects and is a word line WL2 in conductive plug 57B. It connects. At the time of read-out, it is said bit line BL2. And word line

WL2 By minding and detecting the magnetic reluctance between said conductive plugs 57A and 57B, reading appearance of the information written in into said ferromagnetic ring 52 is carried out. With the configuration of drawing 8 , since detection of magnetic reluctance is performed in the direction parallel to the field of the nonmagnetic ring 53 in this way, the absolute value of the magnetic reluctance detected compared with the case where magnetic reluctance is detected, in the direction vertical to the field of a nonmagnetic ring 53 like before increases, the magnetic-reluctance detection by high sensitivity is attained more, and the dependability at the time of read-out improves.
[0029] In this example, even when MRAM50 is dramatically made detailed by forming the ferromagnetic layers 52 and 54 which constitute spin bulb junction in the shape of a ring, it becomes possible to hold magnetization of the ferromagnetic layers 52 and 54 to stability. Moreover, it becomes possible by removing a symmetry axis of rotation inversion to said some of ferromagnetic rings 54, and forming said antiferromagnetism film pattern 56 in it to carry out pinning of the magnetization of said ferromagnetic ring 54 to said circumferencial direction.
[5th example] drawing 9 (A) shows the configuration of MRAM60 by the 5th example of this invention.

[0030] With reference to drawing 9 (A), the conductive plug 62 extends along with a symmetry axis of rotation inversion in the core of said ferromagnetic ring 61 including the ferromagnetic ring 61 with said single MRAM60. Furthermore, a bit line BL is connected to the end of said conductive plug 62, and a word line WL is connected to the other end. Furthermore, said ferromagnetic ring 61 is magnetized by the content of the written-in information in the direction of right-handed rotation, or the direction of left-handed rotation.
[0031] Drawing 9 (B) shows the principle of operation of MRAM60 of drawing 9 (A). When a write-in current which magnetizes said ferromagnetic ring 61 between said bit lines BL and word lines WL in the direction of right-handed rotation which has already existed when said ferromagnetic ring 61 is magnetized in the direction of right-handed rotation with reference to drawing 9 (B) is passed (forward direction), it writes in with time amount and it turns out that a current starts quickly. On the other hand, when said write-in current is passed in the direction which reverses the existing magnetization (hard flow), only the part of the energy which the inversion of said magnetization takes is written in, and the standup of a current is overdue. Then, it becomes possible by detecting the standup property of such a write-in current to read the information written in into said MRAM60.
[0032] Since the information currently written in said ferromagnetic ring will be rewritten when said write-in current is supplied in magnitude which produces reversal of magnetization actually at that time, said read-out actuation serves as destructive read. On the other hand, when the magnitude of said write-in current is restricted to extent which reversal of magnetization does not produce actually, said write-in information is not rewritten and destructive read becomes possible.
[0033] Thus, MRAM60 of drawing 9 (A) can operate as non-volatile random access memory with a very easy configuration.
The configuration of the memory cell array using MRAM explained in the [6th example], next the previous example is explained as the 6th example of this invention.
[0034] Drawing 10 (A) and (B) show the notation of MRAM used by explanation of the following memory cell arrays. Among these, drawing 10 (A) is a notation which shows said MRAM(s) 40, 40A-40C or 50, and drawing 10 (B) is a notation which shows MRAM60 of drawing 9 (A). The notation of drawing 10 (A) is two bit lines BL1 and BL2 like MRAM50 of MRAM40B of drawing 6 , or drawing 8 . Two word lines WL1 and WL2 Although the configuration which it has is supported, other MRAM 40 and 40A or 40C is also said two word lines WL1. And WL2 It is making common connection and expressing is possible.
[0035] Drawing 11 shows the configuration of the memory cell array 70 by the 6th example of said this invention. With reference to drawing 11 , said memory cell array 70 has the configuration which connected to the common bit lines 1 and 2 the memory cells A, B, and C which arranged J in the shape of a matrix respectively from the memory cell A of the configuration corresponding to either of said MRAM(s) 40, 40A-40C, and were further arranged to the line writing direction, and connected to

common word line b the memory cells A, D, and H arranged in the direction of a train. Similarly, the memory cells D, E, and F arranged to the line writing direction are connected to the common bit lines 3 and 4, and the memory cells B, E, and I arranged in the direction of a train are connected to common word line d. The memory cells H, I, and J furthermore arranged to the line writing direction are connected to the common bit lines 5 and 6, and the memory cells C, F, and J arranged in the direction of a train are connected to common word line f.

[0036] If said memory cell A-J is directly connected to these common bit lines 1-6 or the common word lines b, d, and f in that case, since a write-in current or a read-out current will flow the inside of a memory cell array through said common bit line or common word line and will reach to other memory cells, in the memory cell array of drawing 11 , selection transistor TA-TJ is prepared between each memory cell and the corresponding word line. For example, between a memory cell A and corresponding word line b, it turns out that the selection transistor TA is formed. The turn-on of said selection transistor TA is carried out with the selection signal on 2nd common word line a, and, as a result, said memory cell A is electrically connected to word line b. Then, if it writes in the common bit line 1 in this condition and a current is supplied, the information on "0" or "1" will be written in according to the polarity of said write-in current into said memory cell A. In order that the corresponding selection transistors TB and TC may not carry out the turn-on of other memory cells B and C connected to the same common bit line 1 in that case, even if it supplies said write-in current, informational writing is not made in these memory cells. Moreover, the read-out current supplied from said common bit line 2 at the time of read-out does not flow to any memory cells other than the selected memory cell. The above-mentioned explanation is applied to all the memory cells in said memory cell array.

[0037] Then, it becomes possible by choosing either said common word lines a and b, c and d or e and f, and choosing further bit lines 1 and 2, 3 and 4, or 5 and 6 writing and to read about information at the memory cell of arbitration. In order to hold each memory cell in the form of magnetization of information, even if off, the written-in information is not temporarily lost in a power source.

[7th example] drawing 12 shows the configuration of the memory cell array 80 by the 7th example of this invention. However, the same reference mark is given to the part explained previously among drawing 12 , and explanation is omitted.

[0038] With reference to drawing 12 , the turn-on of the selection transistors TA-TI is carried out by this example with the 2nd common bit line 2 and 4 or the selection signal on six. For example, when writing information in said memory cell A, said common bit line 2 is chosen and the turn-on of said selection transistor TA is carried out. The information on desired is written in said memory cell A by choosing the common bit line 1 and common word line a in this condition, passing along said memory cell A from said common bit line 1, writing in the write-in current path which results in said common bit line a, and supplying a current.

[0039] On the other hand, said common word line a is chosen at the same time it chooses said common bit line 2 and carries out the turn-on of said memory cell transistor TA, in reading information from said memory cell A. this condition -- said common bit line 2 to said memory cell A -- a passage -- said -- common -- by [which result in word line a] carrying out reading appearance, carrying out reading appearance to a current path, and supplying a current, reading appearance of the information written in said memory cell A is carried out. Although the turn-on also of the selection transistors TB and TC is carried out in that case, since common word line b or common word line c is not chosen, it reads to memory cells B and C, and a current does not flow. Moreover, since the common bit lines 3, 4, 5, and 6 are not chosen, it reads to other memory cells D, E, and F, or G, H and I, and a current does not flow.

[0040] In this example, by reading to activation of said selection transistor TA-TI, and using the common bit lines 2 and 4 of business, or 6, the common word line for activating a selection transistor currently used in the example of drawing 11 can be omitted, and the configuration of magnetic random access memory is simplified substantially.

[8th example] drawing 13 shows the configuration of the memory cell array 90 by the 8th example of this invention. However, the same reference mark is given to the part explained previously among

drawing 13 , and explanation is omitted.
[0041] The 1st non-line type component DA 1 - DI1 which made l opposite connection and constituted two diodes from this example in the write-in current path about each memory cell A-I with reference to drawing 13 The 2nd non-line type component DA 2 which inserts, reads further and consists of diode into a current path - DI2 It is inserting. Drawing 14 is said 1st non-line type component DA 1. And 2nd non-line type component DA 2 The volt ampere characteristic is compared and shown. However, the inside of drawing 14 and a continuous line are said non-line type component DA 1. About a property, a broken line is the non-line type component DA 2. A property is shown.
[0042] It is said non-line type component DA 1 for referring to drawing 14 . Write-in big electrical-potential-difference +VW which is characterized by the big threshold electrical potential difference TH, and exceeds said threshold electrical potential difference Or -VW It does not flow, unless it impresses. For this reason, it sets to a write-in mode of operation, and is +Vw to said common bit line 1. Or -VW If a write-in electrical potential difference is impressed and word line a is chosen simultaneously, a write-in current will flow to word line a through said memory cell A, and desired writing will be made to said memory cell A. It is said non-line type component DA 1 in that case. Diode DD 2 with which said write-in current collaborates in a memory cell D further even if the big voltage drop corresponding to said threshold electrical potential difference occurs in ends and it does not prepare a selection transistor in each memory cell for this reason Passing, a problem which returns to the common bit line 2 does not arise.
[0043] Moreover, said non-line type component DA 1 which chooses a bit line 1 and word line a at the time of read-out, for example, is further shown in drawing 14 Read-out electrical potential difference VR lower than the threshold electrical potential difference TH By being impressed by said selected bit line 1 reading appearance -- carrying out -- a current -- said 2nd non-line type component DA 2 It passes, and it flows and reading appearance of the information written in into said memory cell A is carried out by [said] carrying out reading appearance and detecting the resistance of said memory cell A based on the value of a current. It is said non-line type component DA 2 in that case. It is the non-line type component DD 2 which passed and flowed to word line a and which reads and collaborates in the memory cell D of others [current], for example, a memory cell. It is prevented and the problem which flows to said memory cell D is not produced.
[0044] According to the configuration of drawing 13 , a word line and a bit line can be set to one per each memory cell, and the configuration of a memory cell array is simplified dramatically. For this reason, the configuration of drawing 13 is suitable for the large-scale memory cell array which accumulated said memory cell by high density. in addition -- this example -- said 1st non-line type component DA 1 - DI1 ****** -- although the component of a configuration of connecting the diode of the couple which counters was used, it is also possible to use the tunnel resonance diode which has a property as shown in drawing 15 .
[9th example] drawing 16 shows the configuration of the memory cell array 100 by the 9th example of this invention. However, the same reference mark is given to the part explained previously among drawing 16 , and explanation is omitted.
[0045] a group arranged to the line writing direction with reference to drawing 16 -- a group which connected with the common bit line 1 with single memory cells A, B, and C in common, and was arranged in the direction of a train -- memory cells A, D, and G are connected common to single common word line a. The same is said of the memory cell groups D, E, and F arranged to the line writing direction or G.H.I and the memory cell groups B, E, and H arranged in the direction of a train, or C, F and I.
[0046] (The non-line type component DA, for example, the non-line type component, 1 of a configuration of having made opposite connection of the diode of a couple by this example between the memory cell A of 1, for example, a memory cell, and the corresponding word line, for example, word line a, at that time It is inserted.) Said non-line type component DA 1 It has a current potential property as previously shown in drawing 14 or drawing 15 . In the memory cell array 100 of this configuration, a bit line 1 and word line a are chosen, for example, and it is said non-line type component DA 1 to said

selected bit line 1. Write-in electrical potential difference VW through which it is made to flow When it impresses, it writes in said memory cell A, a current flows, and the ferromagnetic ring which constitutes said memory cell A is magnetized towards desired. Furthermore, in reading the information written in said memory cell A, as drawing 9 (B) explained previously, said memory cell A is passed, and it detects the standup of the read-out current which reaches said word line a. For this reason, although not illustrated, the comparator which compares reference voltage with a word line electrical potential difference is connected to each word lines a, b, and c. In this example, it may read with a write-in current and a current may be the same.

[0047] By the way, although the write-in current or read-out current which passed the memory cell A chosen by doing in this way, and reached word line a is supplied to other memory cells D and G connected to word line a Said non-line type component DA 1 Non-line type component DD 1 connected to the memory cells D and G non-choosing [these] since the predetermined voltage drop had arisen in case it passes Or DG1 It does not flow, and writes in a non-choosing memory cell, and a current or a read-out current does not flow.

The manufacture approach of MRAM40 explained by the [10th example] next drawing 4 (A), and (B) is explained referring to the top view and sectional view of drawing 17 (A) - drawing 19 (AD). However, said MRAM40 constitutes a part of memory cell array 80 previously explained by drawing 12 from this example.

[0048] With reference to drawing 17 (A) and (B), the field oxide 102 which forms active-region 102A is formed in the front face of the Si substrate 101, and the diffusion fields 101A and 101B are formed into said Si substrate 101 corresponding to said active-region 102A. Furthermore, on said Si substrate 101, corresponding to said diffusion field 101A, corresponding to said diffusion field 101B, the source electrode S is formed in the diffusion field to which the drain electrode D corresponds, respectively again so that ohmic contact may be carried out. Moreover, on said Si substrate 101, among said diffusion fields 101A and 101B, the gate oxide which omitted the graphic display is separated and the gate electrode G is formed. As shown in the top view of drawing 17 (A), said source electrode S extends the inside of a drawing continuously in the vertical direction, and constitutes word line a in the memory cell 80 of drawing 12 . What is necessary is just to form said source electrode S, the drain electrode D, and the gate electrode G by sputtering of for example, Cu film.

[0049] Next, it sets at the process of drawing 17 (C) and (D), and is SiO2 on the structure of drawing 17 (A) and (B). The film 13 so that said source electrode S, the gate electrode G, and the drain electrode D may be covered For example, it deposits on the thickness of about 200nm with a CVD method, it sets at the process of drawing 17 (E) and (F) further, and is said SiO2. On the film 103, the resist film 104 is typically formed after flattening by the CMP process at the thickness of about 200nm. Resist opening 104A corresponding to the core of said drain electrode D is formed in said resist film 104 by photolithography, and it sets to this resist opening 104A, and is said SiO2. By carrying out dry etching of the film 103, it is said SiO2. Into the film 103, opening which exposes said drain electrode D is formed. What is necessary is just to form said opening 104A in the thickness of about 200nm as an example.

[0050] Next, in the process of drawing 17 (G) and (H), the electric conduction film 105, such as Cu or W, and polish recon that carried out the high concentration dope further, is deposited by sputtering on said resist film 104 at the thickness of about 40nm, and the lift off of said electric conduction film 105 is further carried out with said resist film 104 in the process of drawing 17 (I) and (J). Consequently, on said drain electrode D, conductive plug 105A of the same presentation as said electric conduction film 105 is formed corresponding to said resist opening 104.

[0051] Next, it sets at the process of drawing 17 (K) and (L), and is SiO2 on the structure of drawing 17 (I) and (J). With the CVD method using a mono silane and oxygen, the film 106 is typically formed in the thickness of 100nm, is further set at the process of drawing 18 (M) and (N), and it is said SiO2. Etchback of the film 106 is carried out and side-attachment-wall oxide-film 106A is formed in the surroundings of said conductive plug 105A.

[0052] A resist pattern 107 is formed so that said conductive plug 105A and side-attachment-wall oxide

film 106A may furthermore be covered in the process of drawing 18 (O) and (P), and it is SiO2 on it further. An interlayer insulation film 108 is deposited with a CVD method. Furthermore, it sets at the process of drawing 18 (Q) and (R), and is SiO2 on it in said resist pattern 107. The lift off of the film 108 is carried out, and it is said SiO2. Into an interlayer insulation film 108, opening 108A which exposes said conductive plug 105A is formed.

[0053] Next, in the process of drawing 18 (S) and (T), sputtering performs deposition of a FeNi alloy layer and Co layer on the structure of drawing 18 (Q) and (R), bottom ferromagnetism layer 109A corresponding to said ferromagnetic ring 42 is typically formed in the thickness of about 10nm, and thickness forms about 2nm or very thin aluminum layer 109B not more than it by sputtering on it further. Furthermore, the front face of said aluminum layer 109B is oxidized in a pure oxygen ambient atmosphere, and, generally a presentation is AlOx. The insulator layer expressed is formed in the front face of said aluminum layer 109B as said tunnel insulator layer 43. furthermore, said tunnel insulator layer top -- Co layer -- the sequential deposition of the l ** FeNi alloy layer is carried out by sputtering, and upside ferromagnetism layer 109C corresponding to said ferromagnetic ring 44 is typically formed in the thickness of about 10nm. Consequently, the same ferromagnetic ring-like tunnel junction structure MTJ as MRAM40 shown in drawing 4 is formed into opening 108A of said interlayer insulation film 108. Furthermore, the structure shown in drawing 18 (U) and (V) is acquired by grinding and removing nonmagnetic membrane 109B which intervenes said ferromagnetics 109A and 109C which remain on said interlayer insulation film 108, and in between by the CMP method.

[0054] Furthermore, it sets at the process of drawing 19 (W) and (X), and is SiO2 on the structure of drawing 18 (U) and (V). The film 110 accumulates so that said opening 108A may be buried, and it is said SiO2 further. Into the film 110, opening 110A which exposes upside ferromagnetism layer 109C which constitutes said ferromagnetic tunnel junction structure MTJ removes the symmetry axis of rotation inversion of the ferromagnetic tunnel junction structure MTJ of the shape of said ring, and is formed. The antiferromagnetism film 111 and the low resistance electric conduction film 112, such as Cu, which furthermore consist of MnFe, PtMn, etc. on the structure of drawing 19 (W) and (X) in the process of drawing 1919 (Y) and (Z) one by one by sputtering It deposits on the thickness of 10nm and 50nm typically, respectively, and, as a result, antiferromagnetism film pattern 111A corresponding to the antiferromagnetism film pattern 46 on said ferromagnetic ring 44 is formed into said opening 110A. Furthermore, into said opening 110A, low resistance conductivity plug 112A, such as Cu, is formed on said antiferromagnetism film pattern 111A.

[0055] Furthermore, in drawing 19 (AA) and the process of (AB), the CMP method is applied to the structure of drawing 19 (Y) and (Z), and the structure which said interlayer insulation film 108 exposed is formed. In this structure, said conductive plug 112A is exposed on the flattening principal plane of said interlayer insulation film 108. Another interlayer insulation film 113 is deposited so that said interlayer insulation film 108 may be covered on the structure of drawing 19 (AA) and (AB) in the process of drawing 19 (AC). Contact hole 113B which exposes contact hole 113A which penetrates said interlayer insulation film 108 and furthermore exposes said gate electrode G into said interlayer insulation film 113, and said conductive plug 112A is formed. Then, the common bit line BL (2) which constitutes the gate electrode of said selection transistor corresponding to the bit line 2 of drawing 12 and said a part of bit line BL2 (refer to drawing 4 (A)) for read-out is formed by carrying out patterning of the bit line pattern BL (2) which extends in the longitudinal direction in drawing 19 (AC) so that said contact holes 113A and 113B may be covered on said interlayer insulation film 113, as shown in drawing 19 (AC). Furthermore, into said interlayer insulation film 113, opening 113C which exposes conductive plug 105A of said MTJ structure center section is formed, and the common bit line BL (1) which constitutes a part of bit line BL1 (refer to drawing 4 (A)) for writing in said common bit line BL (2) at parallel is formed on said opening 113C.

[0056] By heat-treating all over an external magnetic field further, said antiferromagnetism film pattern 111A is magnetized towards desired, and pinning of magnetization of the upside ferromagnetism ring 44 in the structure of drawing 4 (A) produces the structure of drawing 19 (AC) and (AD). According to the same process, MRAM 40B-40C by other examples, for example, MRAM(s), can be formed.

Furthermore, what is necessary is not to oxidize a front face but just to form upside ferromagnetism layer 109C directly in MRAM50 of a spin bulb mold, in case non-magnetic layer 109B which consists of aluminum in the structure of drawing 1818 (S) and (T) is deposited. Moreover, what is necessary is just to deposit the ferromagnetic layer of a single in the structure of drawing 18 (S) and (T) in MRAM60 of drawing 9 R> 9 (A).
[11th example] drawing 20 (A) - drawing 22 (Q) show the production process of MRAM40 by the 11th example of this invention. This example is suitable for constituting the memory cell array 80 of drawing 12 by said MRAM40 like the previous example.
[0057] With reference to drawing 20 (A), it has the polish recon source electrode S formed in the both sides of the polish recon gate electrode G embedded into the insulator layer 202, and said polish recon gate electrode G, and the drain electrode D on the Si substrate 201, and the diffusion fields 201A and 201B are formed into said Si substrate 201 corresponding to said source electrode S. With the structure of drawing 20 (A), said polish recon gate electrode G and the source electrode S, and the drain electrode D are exposed to the front face of said insulator layer 202. The ferromagnetic 203 which has the laminated structure which carried out the laminating of the Co layer on the FeNi layer on said insulator layer 202, The laminated structure 206 which consists of a ferromagnetic 205 which has the laminated structure which carried out the laminating of Co layer formed on the nonmagnetic membrane 204 which consists of aluminum preferably, and said nonmagnetic membrane 204, and the FeNi layer is formed. For thickness, in the front face of said aluminum layer 204, a presentation is AlOx less than [about 2nm or it] in that case. The tunnel insulator layer expressed is formed.
[0058] Next, in the process of drawing 20 (B) and (C), patterning of the laminated structure 206 of drawing 20 (A) is carried out, and as shown in the top view of drawing 20 (C) on said drain electrode, the ferromagnetic tunnel junction structure MTJ of a disk configuration is formed. In the structure of drawing 20 (D) and (E) furthermore, around the ferromagnetic tunnel junction structure MTJ of drawing 20 (B) and (C) SiO2 The becoming side-attachment-wall insulator layer 207 is formed, and it sets in the structure of drawing 20 (F) and (G). On the structure of drawing 20 (D) and (E), the antiferromagnetism layer 208 which consists of PtMn or FeMn is formed so that the upside ferromagnetism layer 205 of said ferromagnetic tunnel junction structure MTJ may be contacted electrically.
[0059] Furthermore, in the process of drawing 21 (H) and (I), patterning of said antiferromagnetism layer 208 is carried out, and said gate electrode G and said ferromagnetic layer 205 are connected electrically. However, said antiferromagnetism layer 208 is electrically insulated from the side-attachment-wall side of said ferromagnetic tunnel junction structure MTJ by said side-attachment-wall insulator layer 207. furthermore, the process of drawing 21 R> 1 (J) and (K) -- setting -- the structure top of drawing 21 (H) and (I) -- SiO2 etc. -- the becoming interlayer insulation film 209 accumulates, the center section of said ferromagnetic tunnel junction is penetrated after a flat chemically-modified [by the CMP method] degree, and opening 209A which exposes said drain electrode D is formed.
[0060] Furthermore, in the process of drawing 22 (N) and (O), the side-attachment-wall insulator layer 210 is formed on the side-attachment-wall side of said opening 209A, and the conductive plug 211 which becomes from W or Cu inside said side-attachment-wall insulator layer 210 is further formed among said said opening 209A. If it summarizes, this invention will offer a thing below.
[0061] (1) The 1st ferromagnetic and the 2nd ferromagnetic which adjoins said 1st ferromagnetic, is formed and has the fixed magnetization, The ferromagnetic tunnel junction structure which consists of a tunnel insulator layer pinched between said 1st and 2nd ferromagnetics, The conductive plug which penetrates said the 1st ferromagnetic, said tunnel insulator layer, and said 2nd ferromagnetic along with a medial axis, It has the 1st selection line connected to the 1st edge of said conductive plug, and the 2nd selection line connected to the 2nd edge of an opposite hand of said conductive plug. Said 1st magnetic film It is the ferromagnetic tunnel junction random access memory which has a ring-like configuration surrounding said conductive plug, is insulated from said conductive plug, gets down, and is characterized by either of said 1st and 2nd ferromagnetics supporting an antiferromagnetism film pattern to the part.
[0062] (2) Said antiferromagnetism film pattern is ferromagnetic tunnel junction random access memory

given in (1) characterized by extending the surroundings of said medial axis at the include angle of 180 degrees or less.
(3) The 1st ferromagnetic and the 2nd ferromagnetic which adjoins said 1st ferromagnetic, is formed and has the fixed magnetization, The ferromagnetic tunnel junction structure which consists of a tunnel insulator layer pinched between said 1st and 2nd ferromagnetics, The conductive plug which penetrates said the 1st ferromagnetic, said tunnel insulator layer, and said 2nd ferromagnetic along with a medial axis, It has the 1st selection line connected to the 1st edge of said conductive plug, and the 2nd selection line connected to the 2nd edge of an opposite hand of said conductive plug. Said 1st magnetic film It is the ferromagnetic tunnel junction random access memory which has a ring-like configuration surrounding said conductive plug, is insulated from said conductive plug, gets down, and is characterized by one ferromagnetic of said ferromagnetics of the 1st and 2 having larger coercive force than the ferromagnetic of said another side.
[0063] (4) Said 1st and 2nd magnetic films are ferromagnetic tunnel junction random access memory given [among (1) - (3) characterized by having a ring-like configuration surrounding said conductive plug] in any 1 term.
(5) Said conductive plug is ferromagnetic tunnel junction random access memory given [among (1) - (4) characterized by covering the side-attachment-wall side by the insulator layer] in any 1 term.
[0064] (6) Ferromagnetic tunnel junction random access memory given [among (1) - (5) furthermore characterized by avoiding said conductive plug and connecting the 3rd selection line electrically on said 1st ferromagnetic] in any 1 term.
(7) Ferromagnetic tunnel junction random access memory given in (6) characterized by avoiding said conductive plug and furthermore connecting the 4th selection line electrically on said 2nd ferromagnetic.

[0065] (8) Said 2nd selection line is ferromagnetic tunnel junction random access memory given in (6) characterized by consisting of a conductor pattern which connects electrically said the 2nd edge and said 2nd ferromagnetic of said conductive plug.
(9) It is the ferromagnetic tunnel junction random access memory given in (8) which said antiferromagnetism film pattern is supported on said 1st ferromagnetic, and is characterized by connecting said 3rd selection line to said 1st ferromagnetic through said antiferromagnetism film pattern.
[0066] (10) Said conductor pattern is ferromagnetic tunnel junction random access memory (8) characterized by the thing which was formed on the diffusion field formed into the semi-conductor substrate, and to require, or given in (9).
(11) Said diffusion field is ferromagnetic tunnel junction random access memory given in (10) characterized by constituting a part of transistor formed on said semi-conductor substrate.
[0067] (12) The 1st ferromagnetic and the 2nd ferromagnetic which was adjoined and formed in said 1st ferromagnetic and which has the fixed magnetization, The spin bulb junction structure which consists of nonmagnetic electric conduction film pinched between said 1st and 2nd ferromagnetics, Said the 1st ferromagnetic, said tunnel insulator layer, and said 2nd ferromagnetic are penetrated for the inside of said spin bulb junction structure. The conductive plug which extends along with a medial axis, and the 1st selection line connected to the 1st edge of said conductive plug, The 2nd selection line connected to the 2nd edge of an opposite hand of said conductive plug, The 3rd selection line connected to the 1st location on the side-attachment-wall side of said spin bulb junction structure, It has the 4th selection line connected to the 2nd location which counters said 1st location on said side-attachment-wall side of said spin bulb junction structure. Said 1st magnetic film It is the spin bulb random access memory which has a ring-like configuration surrounding said conductive plug, is insulated from said conductive plug, gets down, and is characterized by either of said 1st and 2nd ferromagnetics supporting an antiferromagnetism film pattern to the part.
[0068] (13) Said antiferromagnetism film pattern is spin bulb random access memory given in (12) characterized by extending the surroundings of said medial axis at the include angle of 180 degrees or less.

(14) The 1st ferromagnetic and the 2nd ferromagnetic which was adjoined and formed in said 1st ferromagnetic and which has the fixed magnetization, The spin bulb junction structure which consists of nonmagnetic electric conduction film pinched between said 1st and 2nd ferromagnetics, Said the 1st ferromagnetic, said tunnel insulator layer, and said 2nd ferromagnetic are penetrated for the inside of said spin bulb junction structure. The conductive plug which extends along with a medial axis, and the 1st selection line connected to the 1st edge of said conductive plug, The 2nd selection line connected to the 2nd edge of an opposite hand of said conductive plug, The 3rd selection line connected to the 1st location on the side-attachment-wall side of said spin bulb junction structure, It has the 4th selection line connected to the 2nd location which counters said 1st location on said side-attachment-wall side of said spin bulb junction structure. Said 1st magnetic film It is the spin bulb random access memory which has a ring-like configuration surrounding said conductive plug, is insulated from said conductive plug, gets down, and is characterized by one ferromagnetic of said 1st and 2nd ferromagnetics having larger coercive force than the ferromagnetic of said another side.

[0069] (15) Said 1st and 2nd magnetic films are spin bulb random access memory given [among (12) - (14) characterized by having a ring-like configuration surrounding said conductive plug] in any 1 term.

(16) Said conductive plug is spin bulb random access memory given [among (12) - (15) characterized by covering the side-attachment-wall side by the insulator layer] in any 1 term.

[0070] (17) It is the single ferromagnetic random access memory characterized by consisting of a ferromagnetic, the conductive plug which penetrates the center section of said ferromagnetic, the 1st selection line connected to the 1st edge of said conductive plug, and the 2nd selection line connected to the 2nd edge of an opposite hand of said conductive plug, and for said ferromagnetic having a ring-like configuration surrounding said conductive plug, and insulating from said conductive plug.

[0071] (18) In the memory cell array which arranged two or more memory cells which consist of ferromagnetic tunnel junction random access memory which has the configuration which each indicated to claim 8 in the shape of a matrix a group which aligned in the 1st direction into said memory cell array -- a memory cell Said 1st selection line is connected to the 1st common selection line which extends in said 1st direction in the inside of said magnetic memory cell array. For said 3rd selection line, the inside of said memory cell array in said 1st direction a group which aligned in the direction in which it connected with the 2nd common selection line which extends on said 1st common selection line at parallel, and the 2nd differed in said memory cell array -- a memory cell It is the memory cell array which is connected to the 3rd common selection line which extends the inside of said memory cell array in said 2nd direction in said 2nd selection line, and is characterized by each memory cell including the switch inserted between said 3rd common selection line and said 2nd selection line.

[0072] (19) said -- a switch -- said -- a memory cell -- an array -- inside -- said -- the -- two -- a direction -- said -- the -- three -- common -- selection -- a line -- parallel -- extending -- the -- four -- common -- selection -- a line -- connecting -- having -- said -- the -- four -- common -- selection -- a line -- a top -- a signal -- flowing -- a transistor -- becoming -- things -- the description -- ** -- carrying out -- (-- 18 --) -- a publication -- a memory cell -- an array .

(20) Said switch is a memory cell array given in (18) characterized by consisting of a transistor which is connected to said 2nd common selection line, and flows with the signal on said 2nd common selection line.

[0073] (21) In the memory cell array which arranged two or more memory cells which consist of ferromagnetic tunnel junction random access memory which has the configuration which each indicated to claim 7 in the shape of a matrix a group which aligned in the 1st direction into said memory cell array -- a memory cell Said 1st and 3rd selection lines are connected to the 1st common selection line which extends in said 1st direction in the inside of said magnetic memory cell array. a group which aligned in the direction in which the 2nd differed in said memory cell array -- a memory cell Said 2nd and 4th selection lines are connected to the 2nd common selection line which extends in said 2nd direction in the inside of said memory cell array. Each memory cell The 1st diode inserted between said 2nd common selection line and said 2nd selection line, The memory cell array characterized by having a different property from said 1st diode and said 2nd diode including the 2nd diode inserted between said 2nd

common selection line and said 4th selection line.
[0074] (22) Said 1st diode is a memory cell array given in (21) characterized by being negative resistance diode.
(23) In the memory cell array which arranged two or more memory cells which consist of spin bulb random access memory which has the configuration which each indicated to claim 12 in the shape of a matrix a group which aligned in the 1st direction into said memory cell array -- a memory cell Said 1st and 3rd selection lines are connected to the 1st common selection line which extends in said 1st direction in the inside of said magnetic memory cell array. a group which aligned in the direction in which the 2nd differed in said memory cell array -- a memory cell Said 2nd and 4th selection lines are connected to the 2nd common selection line which extends in said 2nd direction in the inside of said memory cell array. Each memory cell The 1st diode inserted between said 2nd common selection line and said 2nd selection line, The memory cell array characterized by having a different property from said 1st diode and said 2nd diode including the 2nd diode inserted between said 2nd common selection line and said 4th selection line. (24) Said 1st diode is a memory cell array given in (23) characterized by being negative resistance diode.
[0075] (25) In the memory cell array which arranged two or more magnetic random access memory respectively indicated to (17) in the shape of a matrix a group which aligned in the 1st direction into said memory cell array -- a memory cell Said 1st selection line is connected to the 1st common selection line which extends in said 1st direction in the inside of said magnetic memory cell array. a group which aligned in the direction in which the 2nd differed in said memory cell array -- a memory cell It is the memory cell array which is connected to the 2nd common selection line which extends the inside of said memory cell array in said 2nd direction in said 2nd selection line, and is characterized by inserting diode in each memory cell between said 2nd common selection line and said 2nd selection line.
[0076] (26) The aforementioned diode is a memory cell array given in (25) characterized by being negative resistance diode. As mentioned above, although this invention was explained about the desirable example, various ****** and modification are possible for this invention in the summary which it is not limited to the above-mentioned specific example, and was indicated to the claim.
[0077]
[Effect of the Invention] According to this invention, in case magnetic random access memory is formed using a ferromagnetic tunnel junction or spin bulb junction, by forming the ferromagnetic layer which constitutes said ferromagnetic tunnel junction or spin bulb junction in the shape of a ring, also when said magnetic random access memory is dramatically made detailed, the problem from which the magnetization direction of a ferromagnetic layer changes with reflux magnetic fields is avoided, and stable writing or read-out actuation can be realized. In order to magnetize said ferromagnetic layer in accordance with a ring configuration and to carry out pinning of this magnetization in that case, an antiferromagnetism film pattern is formed in the part which separated from the symmetry axis of rotation inversion on a pinned layer in this invention. Such a configuration enables it to carry out pinning of the magnetization direction of said ring-like pinned layer in the direction of the circumference of a right hand, or the direction of the circumference of a left hand by magnetizing said antiferromagnetism film pattern to an one direction.
[0078] Furthermore, according to this invention, it is also possible to read with a part of write-in current path, and to form a current path independently to single ferromagnetic tunnel junction structure or spin bulb junction, but it becomes possible to reduce the number of the bit line at the time of constituting a memory cell array from sharing a part, or word lines. Furthermore, this invention offers the magnetic random access memory of the very easy configuration using a single ferromagnetic ring. The random access memory using this single ferromagnetic ring can be driven with a single bit line and a single word line, and the configuration of a memory cell array is simplified dramatically. Moreover, the accumulation consistency of a memory cell array can be raised in connection with this.
[0079] Furthermore, according to this invention, it sets to the memory cell array formed by arranging this magnetic random access memory as a memory cell. Selection of the memory cell of 1, i.e., supply of a write-in current, and supply of a read-out current The problem made also to other memory cells

connected through the word line or the bit line is avoided by preparing a selection transistor or other non-line type components corresponding to each memory cell.

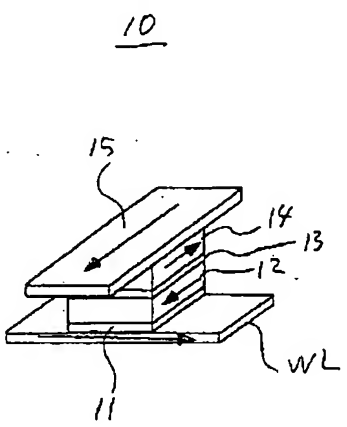
[Translation done.]

* NOTICES *

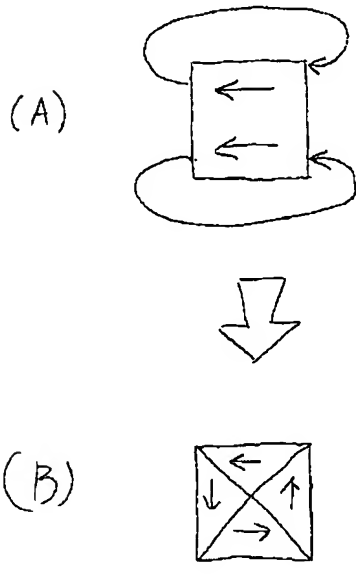
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

[Drawing 1]
従来の磁気ランダムアクセスメモリの構成を示す図



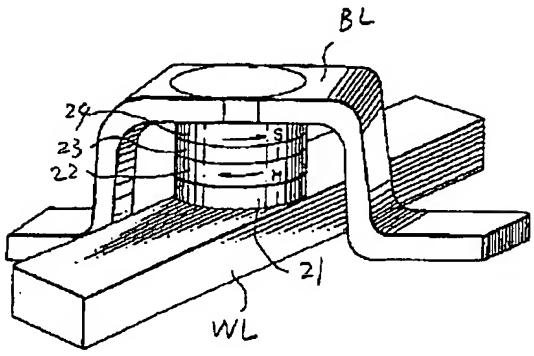
[Drawing 2]
(A)，(B)は、図1の磁気ランダムアクセスメモリの問題点を説明する図



[Drawing 3]

従来の別の磁気ランダムアクセスメモリの構成を示す図

20

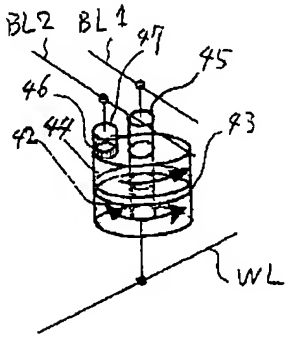


[Drawing 4]

（A），（B）は、本発明の第1実施例による磁気ランダムアクセスメモリの構成を示す図

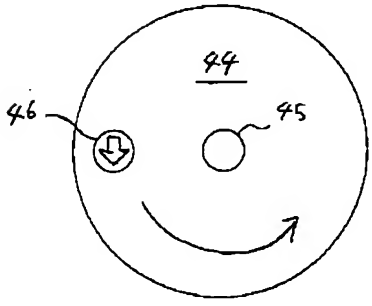
40

(A)



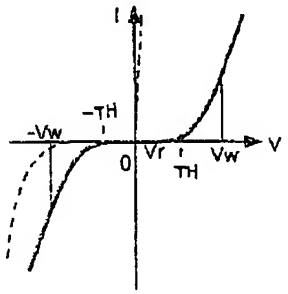
40

(B)



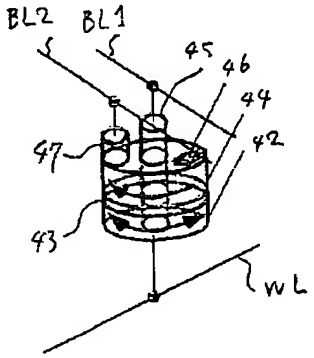
[Drawing 14]

図１３の実施例で使われる非線型素子の特性を示す図



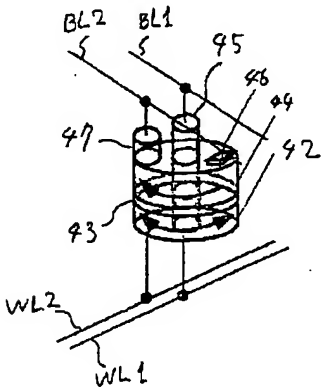
[Drawing 5]

図４（A），（B）の磁気ランダムアクセスメモリの一変形例を示す図



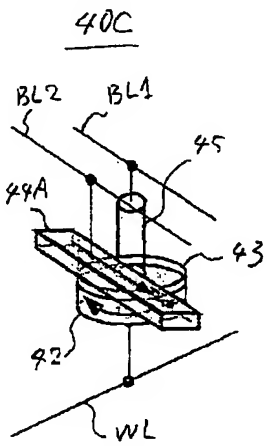
[Drawing 6]

本発明の第２実施例による磁気ランダムアクセスメモリの構成を示す図



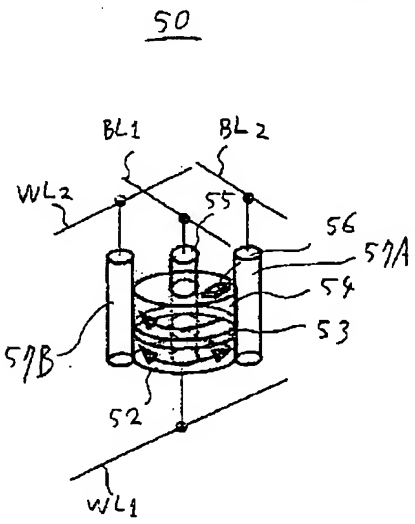
[Drawing 7]

本発明の第３実施例による磁気ランダムアクセスメモリの構成を示す図



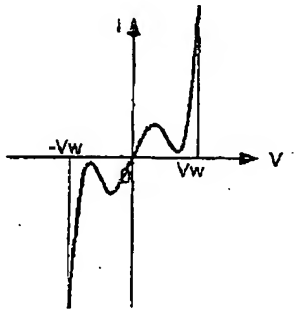
[Drawing 8]

本発明の第４実施例による磁気ランダムアクセスメモリの構成を示す図



[Drawing 15]

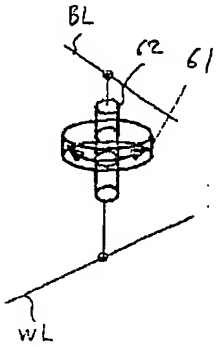
図１３の実施例で使われる別の非線型素子の特性を示す図



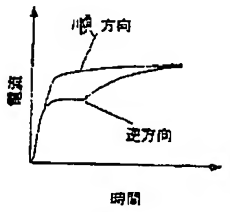
[Drawing 9]

(A)，(B) 本発明の第5実施例による磁気ランダムアクセスメモリの構成および動作を示す図

(A)



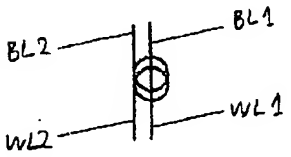
(B)



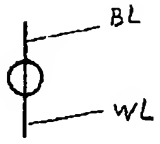
[Drawing 10]

(A)，(B) は、本発明で使われる記号を説明する図

(A)



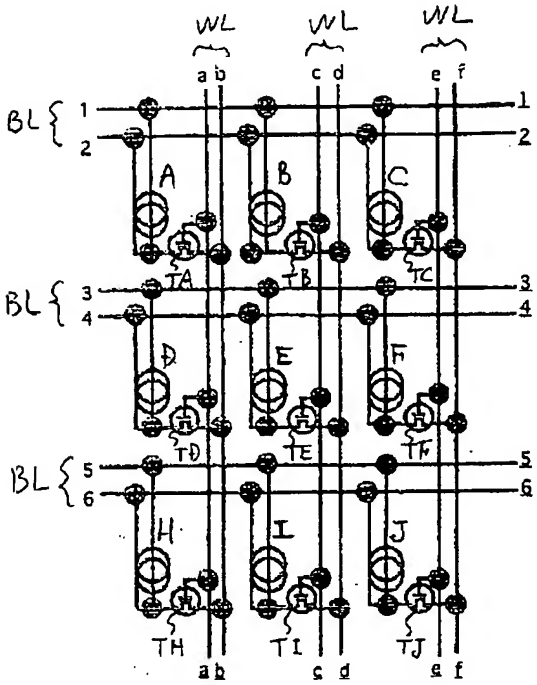
(B)



[Drawing 11]

本発明の第6実施例によるメモリセルアレイの構成を示す図

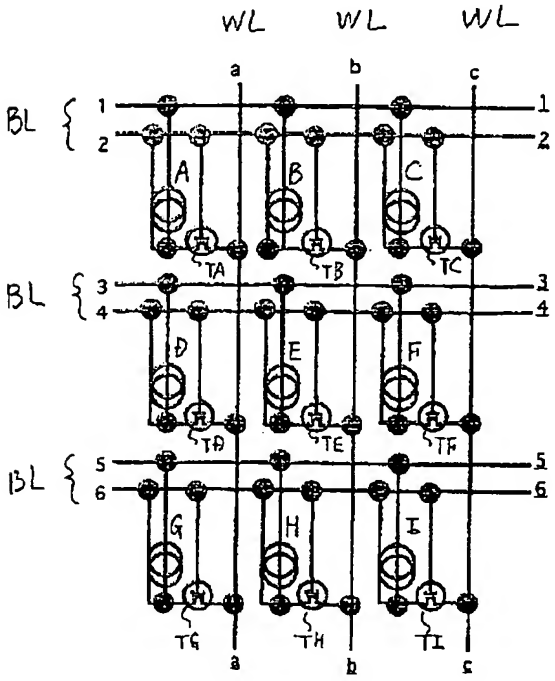
70



[Drawing 12]

本発明の第7実施例によるメモリセルアレイの構成を示す図

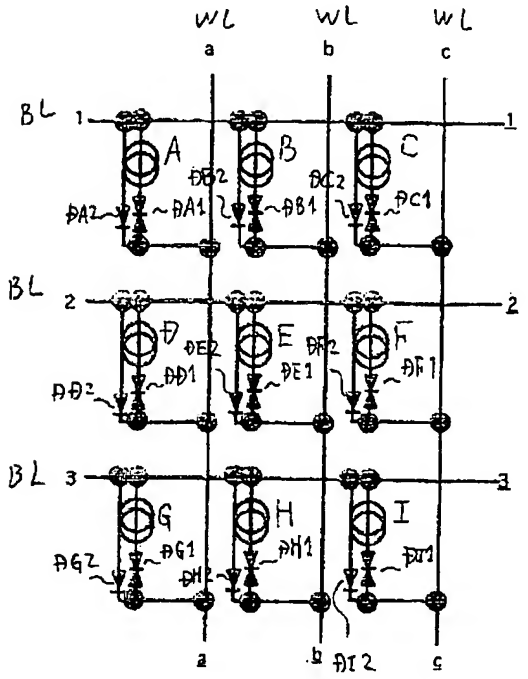
80



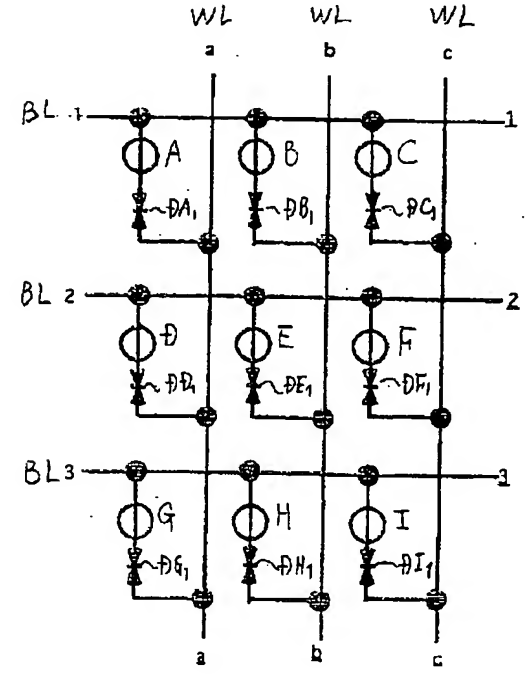
[Drawing 13]

本発明の第8実施例によるメモリセルアレイの構成を示す図

90

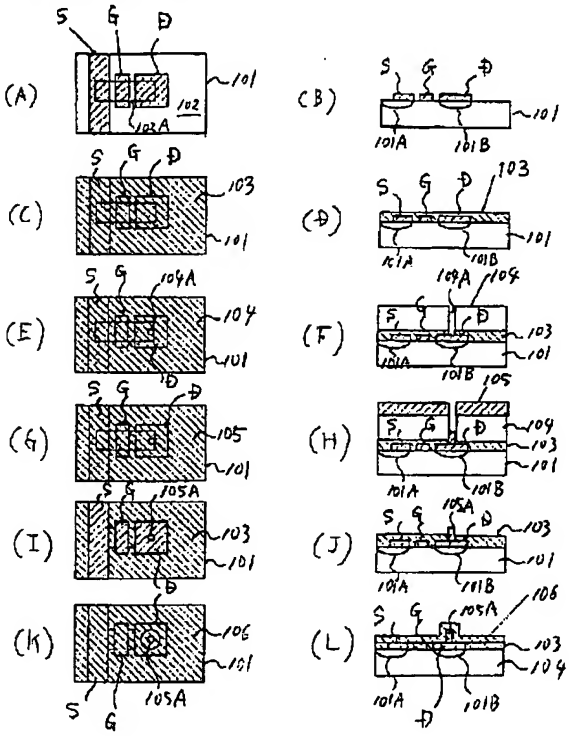


[Drawing 16]
本発明の第8実施例によるメモリセルアレイの構成を示す図



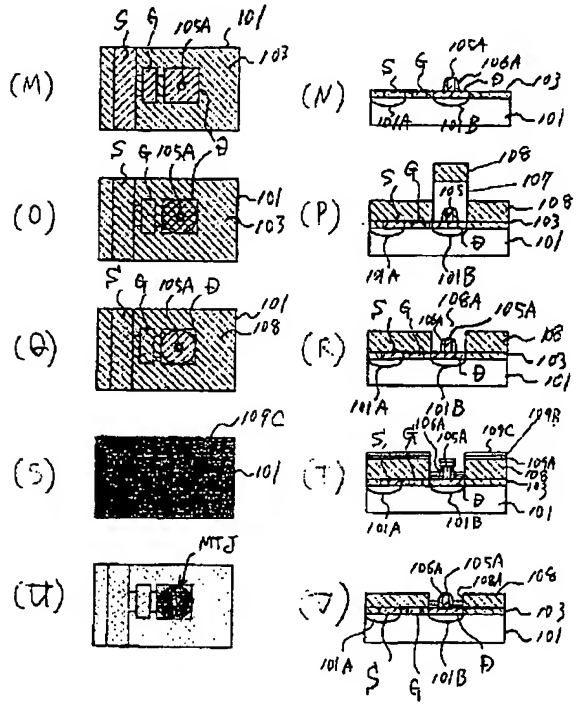
[Drawing 17]

（A）～（L）は、本発明の第１０実施例による磁気ランダムアクセスメモリの製造工程を説明する図（その１）



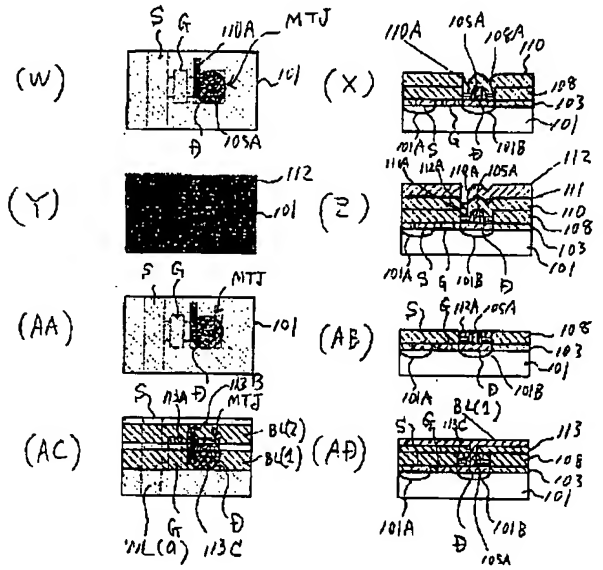
[Drawing 18]

（M）～（V）は、本発明の第１０実施例による磁気ランダムアクセスメモリの製造工程を説明する図（その２）



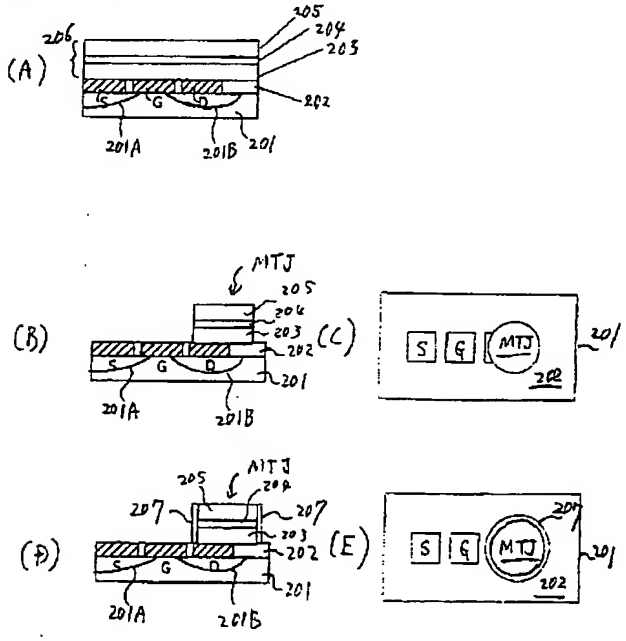
[Drawing 19]

(W) ～ (AD) は、本発明の第１０実施例による磁気ランダムアクセスメモリの製造工程を説明する図（その３）



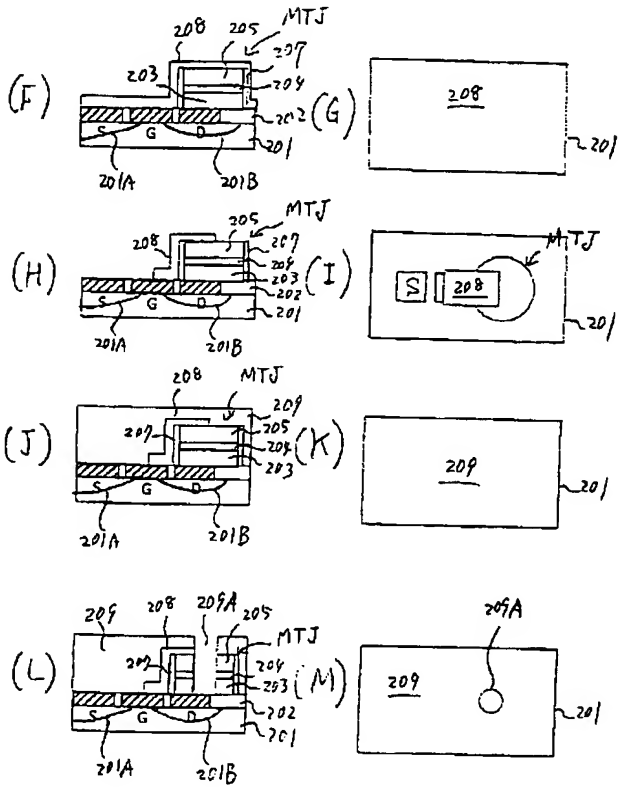
[Drawing 20]

(A) ～ (E) は、本発明の第１１実施例による磁気ランダムアクセスメモリの製造工程を説明する図（その１）



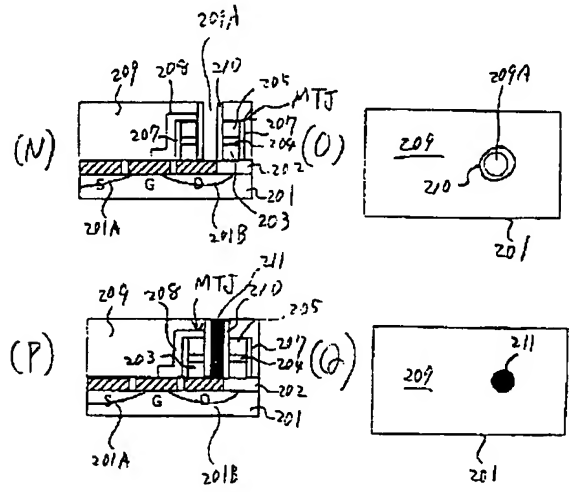
[Drawing 21]

（F）～（M）は、本発明の第１１実施例による磁気ランダムアクセスメモリの製造工程を説明する図（その２）



[Drawing 22]

（N）～（Q）は、本発明の第１１実施例による磁気ランダムアクセスメモリの製造工程を説明する図（その３）



[Translation done.]